



Global Precipitation Particle Sizes by Global Precipitation Measurement Mission: A Comparison Study with DPR and CMB Data

Mei Han^{1,2}, Scott A. Braun²

¹Goddard Earth Science Technology and Research, Morgan State University; ²Mesoscale Atmospheric Processes Laboratory, NASA/GSFC



I. INTRODUCTION

The Global Precipitation Measurement (GPM) core satellite carries the first spaceborne dual-frequency precipitation radar (DPR) at Ka (35 GHz) and Ku (13 GHz) frequencies and a 13-channel passive microwave imager (GMI). One of the advancements is that it quantitatively estimates the precipitation particle size distributions. The estimated size parameter, mass-weighted mean diameter, D_m , offers new physical insights into microphysical properties of precipitation around the globe.

D_m is retrieved with two sets of algorithms. One is based on the DPR observations only, the other one uses observations from DPR and GMI, called the combined (CMB) product. We compare D_m in level-2 (swath data) and level-3 (gridded) products of both algorithms. In this study, 5 years of data are examined to investigate the structure of individual storms and global patterns of D_m at different vertical levels. The characteristics of D_m in stratiform vs. convective precipitation, the seasonal and zonal variations of D_m are also investigated.

II. 5 CASES OF PRECIPITATION PARTICLE SIZES

Fig. 1: DPR Ku Reflectivity horizontal view (top) and along-track cross sectional view (bottom)

We chose 5 cases to illustrate the structure of storms and the distribution of D_m within the storms.

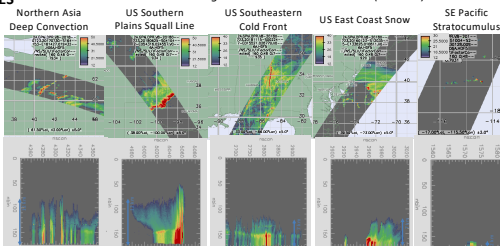
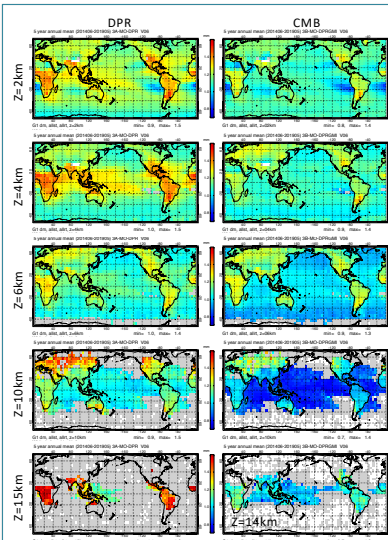
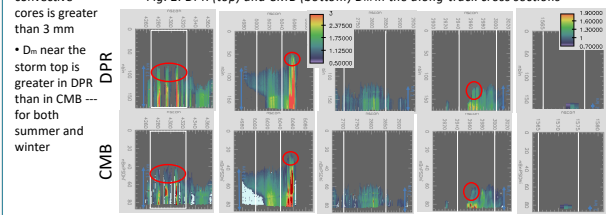


Fig. 2: DPR (top) and CMB (bottom) D_m in the along-track cross sections



III. ANNUAL MEAN OF PRECIPITATION PARTICLE SIZE

Fig. 3: DPR vs. CMB 5-year mean D_m from June 2014 to May 2019 at 5 vertical levels. (white shade: no observations; Gray shade: less than 0.01% occurrence)

- CMB D_m is generally smaller than DPR D_m
- At Z=2km, largest D_m occurs in central Africa, Himalayas foothills, US southern plains, and Argentina.

- In DPR, from Z=2 to 4 km, D_m increases in the tropics, but decreases slightly in the mid-to-high latitudes.

- In CMB, from Z=2 to 4 km, D_m decreases slightly over the tropical land and high latitude ocean, but increases over Eurasian and North America (NA) high latitude land.

- At Z=6 km, DPR and CMB are mostly similar over land
- At Z=10 km, large D_m occurs over Eurasian and NA high-lat land.

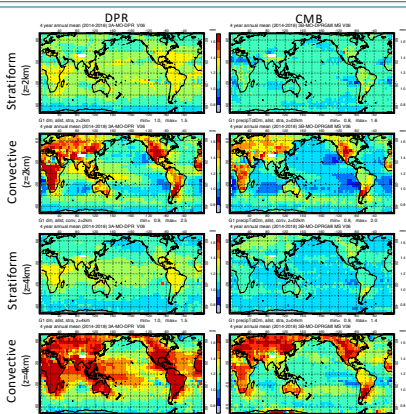
- At Z=15 km, large D_m occurs over low- and mid-latitude land.
- At Z=2 km, small D_m occurs in subtropical eastern ocean basins -- marine stratocumulus

IV. DPR D_m Occurrence and CONVECTIVE FRACTION

Fig. 4: DPR D_m probability (left) and DPR convective fraction (right)

The fraction of convective precipitation is calculated to help us understand the characteristics of D_m shown in the previous figures. Generally, the detection of a bright band determines stratiform rain.

- Small but not negligible occurrence at marine stratocumulus regions
- Over the ocean, subtropics have high convective fraction. Eastern oceans may correspond to warm rain with no bright band.
- At Z=10 km, high convective fraction in the Northern Hemisphere high latitudes corresponds to large D_m .
- At Z=15 km, high convective fraction indicates that only deep convection can reach such high altitudes.



V. STRATIFORM VS CONVECTIVE

Fig. 5: DPR vs CMB Stratiform and convective D_m at Z=2 and 4 km

- Convective precipitation has larger D_m than stratiform precipitation at all levels.
- Large- D_m convection is prominent over land.
- CMB lacks low-latitude D_m max over ocean for both stratiform and convective
- DPR D_m is larger than CMB D_m , except the stratiform over Eurasian and NA higher lat. land at Z=4km

VI. SCATTER PLOT AND GLOBAL MEAN D_m

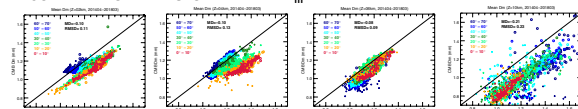


Fig. 6: Scatter plot of CMB vs. DPR, color-coded by latitudes, circles for N. Heml., crosses for S. Heml.

- At Z=2 and 4 km, largest differences occur at low latitudes
- At Z=2 km, DPR has larger D_m except to the south of 60° S (Antarctic), and northern high-lat. (Greenland, and Iceland)
- At Z=4 km, largest RMSD, differences clustered by low vs high lat.
- At Z=6 km, smallest differences
- At Z=10 km, largest MD and RMSD
- In Fig. 7, DPR convection contributes to large mean D_m

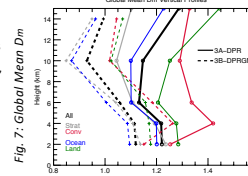


Fig. 7: Global Mean D_m

VII. SEASONAL VARIATIONS AND ZONAL MEAN D_m

- Distinct seasonal variation of D_m in the cold vs. warm seasons, especially over land.
- CMB has similar pattern as DPR

- NH winter, contrasts between oceanic storm tracks vs Eurasian and NA land are distinct in DPR, but not in CMB.

- Seasonal variation in CMB is weak at high-lat, mainly due to lack of variations over land.

- To the north of 50N, over ocean, DPR has larger D_m in summer, while CMB has larger D_m in winter

- At Z=4 km, seasonal and latitudinal variations in CMB are small, particularly over the ocean

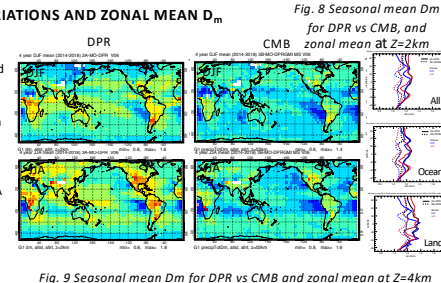
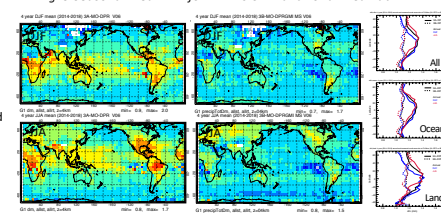
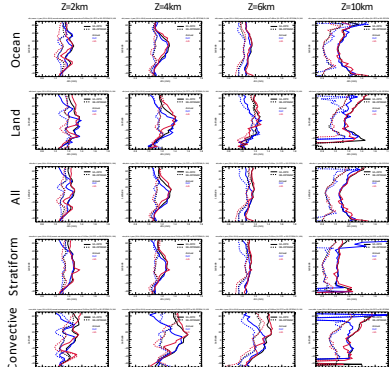


Fig. 9 Seasonal mean D_m for DPR vs CMB and zonal mean at Z=4km



VIII. ZONAL MEAN D_m

Fig. 10: Zonal mean D_m (2014-2018) at different altitudes for ocean vs land, all samples (3rd row), and stratiform vs convective



- At Z=2 km, lack of contrast between the storm track and high-lat in winter is clearly shown in stratiform, not convective.
- At Z=4 km, in the tropics, DPR D_m appears to be the largest among all levels; but CMB does not have much latitudinal variations
- At Z=6 km, DPR and CMB have the smallest difference
- At Z=10 km, D_m at high-lat are larger than low-lat, largely due to the convective component.

IV. MD AND RMSD

The mean difference (MD) and root mean square difference (RMSD)

- MD and RMSD grow larger from low to high levels -- Also see Figs. 6 and 7
- Convective has larger MD and RMSD than stratiform
- Ocean often has larger MD and RMSD than land, especially at Z=6 km, where MD and RMSD values are the smallest

Table 1. MD and RMSD between CMB and DPR at Z=2, 4, 6, and 10 km

Z (km)	2	4	6	10
MD All	-0.1015	-0.1038	-0.0752	-0.211
MD Strat	-0.0987	-0.0863	-0.0646	-0.1933
MD Conv	-0.1025	-0.157	-0.1547	-0.2729
MD Ocean	-0.1055	-0.1123	-0.0862	-0.2173
MD Land	-0.0975	-0.0959	-0.0326	-0.2093
RMSD All	0.1146	0.1349	0.0874	0.231
RMSD Strat	0.1122	0.1142	0.0856	0.2118
RMSD Conv	0.1269	0.2343	0.1698	0.2997
RMSD Ocean	0.1195	0.1391	0.1029	0.2428
RMSD Land	0.1202	0.1474	0.0637	0.2246

X. SUMMARY

We analyzed five years of GPM DPR and CMB data to study precipitation particles sizes over the globe. Particle size distributions show clear contrasts over land vs. ocean, with distinct variations as a function of season, latitude, and altitude. Global patterns of the DPR and CMB retrievals agree with early studies. Mean D_m is generally larger at low levels than at middle levels. Large particles due to convection are found at high levels over high altitudes land. Systematic differences between CMB and DPR are found corresponding to single storms' structures, latitudes, altitudes, seasons, rain types, geolocations, and climate. The global mean D_m in CMB is 0.1 mm smaller than that in DPR at Z=2 and 4 km.